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Quarterly Progress Report

October-December 1992

A VIRTUAL ENVIRONMENT FOR MANUFACTURING SYSTEMS

ONR Grant N00014-92-J-4092

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Although this project officially began on October 1, 1992, preliminary research and project initiation activities took place during the late summer and early fall of 1992. This is the first quarterly progress report on the project. The following is a brief summary of the progress on each of the three research thrusts described in the original proposal.

Assembly Planning Through Visualization

From October to December 1992, the research on Assembly Planning Through Visualization has been focused on the development and implementation of algorithms for proposing disassembly trajectories. Three graduate students are currently involved in this research under the supervision of Dr. Lin-Lin Chen.

One of the graduate students has been working on the development of a new set of algorithms for generating potential assembly/disassembly directions for components with free-form surfaces. To generate potentially feasible disassembly directions, an O(n^2 alpha(n)) time algorithm has been developed for computing the spherical convex hull of a possibly self intersecting spherical curve consisting of n algebraic curved segments, where alpha(n) is the functional inverse of Ackermann's function and is a extremely slow growing function of n.

Another graduate student has been working on the development of an interactive tool for visualizing a Bezier surface and its corresponding Gaussian Map formed by translating the unit surface normals at the points on the surface to the origin. The Gaussian Map of a surface will be the input to the previously mentioned spherical convex hull algorithm. This interactive tool allows the control points that define the surface to be interactively edited and displays the resulting Gaussian Map. Concurrently, another graduate student has implemented Woo and Dutta's algorithm for generating an assembly/disassembly plan of a two-dimensional assembly. As an initial effort, this program takes a AUTOCAD DXF file that describes an assembly as input and computes a disassembly plan.

Off-line Programming and Visualization of Robots

Darren Knapp, an outstanding Masters student, has been hired to head up the off-line programming efforts. Mr. Knapp's research will be supervised by Professor Martin Vanderploeg. Initial efforts are evaluating the current off-line programming software and designing the structure for the next generation of software. The objectives of this new software are to enable modular installation of many robot types and other assembly equipment, and to facilitate high speed graphics that are available using the Silicon Graphics Reality Engine in the Visualization laboratory. In addition, the user interface is being redesigned to accommodate interactive off-line programming of cooperating robots.

Simulation and Verification of Material Removal Processes

A dexel-based representation of workpiece, part, and milling tool has been developed to facilitate real-time visual simulation and dimensional verification of five-axis NC milling processes. Mr. Yunching Huang, a Ph.D. candidate under the guidance of Professor James Oliver, is the primary researcher on this portion of the project. Preliminary results are very encouraging; the method is robust and computationally efficient. A technical paper describing this technique is currently in preparation, and we are investigating the possibility of a patent application. A video tape demonstrating a preliminary implementation of the method will be presented at the ONR Manufacturing Workshop on January 12-14, 1993.

A related research project, funded by NSF, has produced some unexpected results which will soon be incorporated within this project. Mr. Nirmal Nair, an MS student, has been working to develop a sheet metal formability constraint for use in a synthesis algorithm for sculptured surface models. A spin-off from this work is a linear-time algorithm for constant area mapping of non-developable surfaces onto a plane. We are confident that this method can be employed to provide accurate analytical assessment of forming processes, and provide the basis for visual simulation and verification tool for sheet metal forming. Mr. Nair will finish his MS in May of 1993, and will be offered an assistantship on this grant to pursue his doctoral research on virtual environments for forming processes.

Statement A per Dr. Watcher
ONR/Code 1133SS
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2-10-93 JK